

Quality Assessment and Treatment of Hand-Dug Well Water Consumed by Residents of Ajogodo Community in Sapele Local Government Area of Delta State, Nigeria

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Abstract— This study was designed to ascertain the quality of hand-dug well water consumed by residents of Ajogodo community in Sapele Local Government Area of Delta State, Nigeria and the potentials for use of *Moringa oleifera* seeds and aluminium sulphate (Alum) for water purification. The first phase of the study focused on hand-dug well water quality assessment while the second phase involved water treatment experiments to ascertain the individual and synergistic water purification potentials of *Moringa oleifera* seeds and Alum. Assay for physicochemical and microbial parameters was carried out using standard procedures. Results obtained in this study revealed that water quality indicators for the untreated water were above permissible WHO/NSDWQ regulatory limits for potable water. Water samples treated with *Moringa oleifera* seed powder recorded an improvement in water parameters as compared to untreated samples while water samples treated with a blend of alum and *Moringa oleifera* seed powder recorded the best performance and significant reduction in Total Solids ($155.90 \pm 1.37 \text{ mg/l}$), Total Suspended Solids ($27.20 \pm 3.20 \text{ mg/l}$), Total Hardness ($28.10 \pm 0.67 \text{ mg/l}$), Biochemical Oxygen Demand ($3.65 \pm 0.09 \text{ mg/l}$), Nitrite ($0.15 \pm 0.00 \text{ mg/l}$), Calcium (17.73 mg/l), Magnesium (310.27 mg/l), Copper (0.07 mg/l), Total Coliform ($0.47 \pm 0.03 \text{ cfu}$) and *E. coli* ($0.30 \pm 0.06 \text{ cfu}$). Findings from this study revealed that water obtained from hand-dug wells in Ajogodo community is unsafe for drinking and should be treated before consumption. The use of a combination of *Moringa oleifera* seed and alum offers an effective and easy option to purify water before consumption.

I. INTRODUCTION

Water is an essential fluid needed for metabolism in living organisms. It is a major component of the biosphere [1], occupying about 71% of the earth's surface and yet it is one of the scarcest commodities especially in the developing countries of the world. Water is indispensable for man's activities and remain one of the most demanded of all urban and rural amenities [2]. The many usefulness of Water as a resource includes recreation, transportation,

hydroelectric power and domestic, industrial and commercial uses [3].

Water seem to be abundant on planet Earth as a whole, but fresh potable water is not always available at the right time or the right place for use by humans or the ecosystem [4]. The quality of water available for drinking is important for the well-being of humans. Water in its natural form is colourless, odourless, tasteless and sparkling in nature [5]. However, water is said to be

contaminated or polluted if the chemical or physical properties are altered [6].

Although more than three quarters of the Earth's surface is made up of water, only 2.8 percent of the Earth's water is available for human consumption [7]. Different sources introduce different forms of contaminants to water bodies such as dissolved gases, minerals, organic and inorganic substances chemicals etc. If not monitored, they can have adverse effect on living organisms. It is common that most people obtained drinking water from groundwater by digging well or drilling boreholes. The water that is available for use by human whether for drinking, irrigation and industrial processes or for recreation must have some required quality in order to make it acceptable [1].

Over 40% of Nigerians depend on either polluted surface waters or wells for their domestic activities. Constant use of heavily polluted water for a long time usually results in health problems [8]. The ultimate use of water is effective in its pure condition; contaminated water adversely affect habitation. Only 60% of the total population of Nigeria had access to safe drinking water in 2002. The problem is more serious in the rural areas as 51% of the citizens live without safe drinking water [9]. In the presence of contaminated water and the insufficiency of safe access to pure water, consequent deadly diseases contribute great threat to life on the planet. Water-related diseases are major concerns in Nigeria as well as developing countries with polluted water problems. [10]. Purnamitta [11] reported health problems associated with prolonged consumption of polluted water, which range from dysentery, diarrhea, abortion, premature birth, viral hepatitis and gastric and duodenal ulcers amongst others [12].

In Ajogodo Community in Sapele L.G.A of Delta State Nigeria, many house owners dig wells and sink boreholes as sources of water for drinking and domestic purposes. Only a few numbers of the community can afford bottle water; majority of the residents rely more on ground water collected from hand-dug wells. Considering the health risks associated with consumption of contaminated water, it is imperative to carry out quality analysis on water obtained from these hand-dug wells to ascertain the microbiological, physical and chemical properties of the water and establish that they are all within permissible limits for safe Drinking Water.

The aim of the present study therefore, is to ascertain the quality of water collected from the hand-dug well under study and the potentials for use of *Moringa oleifera* seeds and Aluminium sulphate (Alum) for water purification.

II. MATERIALS AND METHODS

2.1 Sampling

2.1.1 Collection of water samples

Water samples were obtained from hand-dug wells located at Ajogodo Community in Sapele LGA of Delta State, Nigeria. Water samples were collected using amber colored bottles. All samples were preserved using ice packs in coolers and analyzed within 9 hours of sample collection. Commercial bottle water was purchased off-the-shelf and used as Control sample. A total of thirty (30) test water samples were collected and analyzed.

2.1.2 Preparation of *Moringa oleifera* seed powder

Dried *Moringa oleifera* seeds were collected from Rivers State University of Science and Technology, Port Harcourt, Rivers State, Nigeria. Good quality *Moringa oleifera* seeds were selected, de-coated, dried and the kernels were ground to fine powder using a blender.

2.1.3 Preparation of Alum

Aluminium sulphate (Alum) was purchase from Choba market in Rivers State, Nigeria. The alum was ground to fine powder and dissolved in de-ionized water.

2.2. Analytical methods

2.2.1 Measurement of pH

Measurement of pH was carried out using the ASTM D 1293 [13].

2.2.2 Determination of Electric conductivity

Electrical Conductivity was determined using the Conductometric method [14].

2.2.3 Determination of Dissolved Oxygen

Dissolved Oxygen was determined using the ALPHA 5210A [15].

2.2.4 Determination of Biochemical Oxygen Demand

Biochemical Oxygen Demand (BOD) was determined using the APHA 5210B method [15].

2.2.5 Measurement of Turbidity

Turbidity was measured using Nephelometric Method (APHA 2130B) [16].

2.2.6 Determination of Total Suspended Solids

Total Suspended Solids was determined according to the APHA 2540-D method APHA [17].

2.2.7 Determination of Total Dissolved solids

Total Dissolved Solid was determined using APHA 2540-C method [18].

2.2.8 Determination of Chloride

Chloride was determined using ASTM D4458 method [19].

2.2.9 Metal Analysis

Metals in water (Sodium, Potassium, Calcium, Copper, Iron, Zinc and Cadmium) were determined using Atomic Absorption Spectrophotometer method [20].

2.2.10 Determination of Total Hardness

Total Hardness was determined using a method described by AOAC [21].

2.2.11 Analysis for microbial parameters

Samples were analyzed according to APHA standard methods [22].

2.3 Statistical Analysis

Results in this study are expressed as Means \pm Standard Error Mean (SEM) while one-way ANOVA was used to test for differences between treatment groups using SPSS version 20. The results were considered significant at p-values of less than 0.05, that is, at 95% confidence level ($P < 0.05$).

III. RESULTS

The various groups involved in the study are defined as in Table 1. The result of chemical, physical and microbiological analyses of hand-dug well water collected from the study area before and after treatment are presented in Tables 2 to 5. Results for experimental samples were compared with Control samples, World Health Organization (WHO) and National Safe Drinking Water Quality (NSDWQ) specifications. Table 2 shows the mean levels of physical characteristics of the samples analysed before and after treatment.

Turbidity values in all the experimental groups were below WHO/NSDWQ acceptable limit for turbidity (5.0 NTU) and varied from 0.47 ± 0.33 to 3.10 ± 0.58 NTU. Conductivity values for all the test groups were below WHO/NSDWQ permissible limit $1000 \mu\text{S}/\text{cm}$ and varied from 128.00 ± 6.00 to $992.00 \pm 4.16 \mu\text{S}/\text{cm}$.

Biochemical Oxygen Demand (BOD) values for test water samples varied from 3.17 ± 0.09 to $6.91 \pm 0.17 \text{mg}/\text{l}$ and significantly lower ($p < 0.05$) when compared to Control group CW ($4.48 \pm 0.14 \text{mg}/\text{l}$). Chemical Oxygen Demand (COD) varied from 9.30 ± 0.40 to $78.85 \pm 0.73 \text{mg}/\text{l}$ with the untreated group WW ($78.85 \pm 0.75 \text{mg}/\text{l}$) and WWMOA ($9.67 \pm 0.44 \text{mg}/\text{l}$) significantly different ($p < 0.05$) compared to Control group CW ($12.21 \pm 0.90 \text{mg}/\text{l}$). Values recorded for alkalinity, phosphate, nitrates and chloride in all test groups were below the respective WHO/NSDWQ permissible limits.

Results for Magnesium ranged from 10.27 ± 0.23 to $84.22 \pm 3.97 \text{mg}/\text{l}$ and significantly different ($p < 0.05$) when compared to group CW ($54.91 \pm 1.85 \text{mg}/\text{l}$) with the untreated water sample showing values ($84.22 \pm 3.97 \text{mg}/\text{l}$) higher than WHO/NSDWQ standards ($50 \text{mg}/\text{l}$).

Results presented in Table 5 showed that total Coliform in groups WW, WWMO, WWA and WWMOA varied from 0.47 ± 0.03 to $12.67 \pm 1.33 \text{Cfu}$ with values for group WW observed to be higher than WHO/NSDWQ permissible limits and also significantly different ($p < 0.05$) from group WW values ($1.00 \pm 0.00 \text{Cfu}$). *Escherichia coli* (E. coli) in the test groups varied from 0.20 ± 0.00 to $12.00 \pm 2.31 \text{Cfu}$ with Group WW recording values higher than the WHO/NSDWQ regulatory standard (0.00Cfu).

IV. DISCUSSION

Turbidity is an indication of suspended solids of different sizes present in water thereby resulting in cloudiness which could be as a result of colloidal particles, sewage wastes and industrial waste in water [23]. After treatment, results showed reduction in the level of turbidity of the test water samples. This corroborates findings from a previous study by Mangale [24] where *Moringa oleifera* seed powder caused decreased water turbidity with increased dosing. Also, Chaudhuri *et al.* [25] also concluded that *Moringa oleifera* seed extract was effective as a primary coagulant and as an adjuvant coagulant for clarifying turbid or coloured water.

Electric conductivity is an aggregate of chemical ions and dissolved matter in water. Some previous studies had shown that most drinking waters have conductivity of less than $1000 \mu\text{S}/\text{cm}$. The mean value for electric conductivity of the water sample as shown in Tables 4.1 and 4.2 before and after treatment were lower than regulatory values.

Results obtained for Total Solids (TS) before treatment were above regulatory values as shown in Tables 1. After treatment with *Moringa oleifera* seed powder and alum, TS was reduced in all groups except the Values are means \pm Standard Error Mean. Values with the same superscript (a) are significantly different at ($p < 0.05$) when compared to control down the group. Values with superscript (b and c) are not statistically significant.

Table 1. Experimental Groups in the study

GROUP	CW	WW	WWMO	WWA	WWMOA
Description/Treatment	Commercial Bottle water	Well water only	Well water + 5g <i>Moringa oleifera</i> seed powder	Well water + 5g alum	Well water + 5g <i>Moringa oleifera</i> seed powder + 5g alum

Table 2. Mean levels of physical parameters before and after treatment (As compared with Control-Bottled water).

Group	Turbidity (NTU)	E.C(μs/cm)	TS(mg/l)	TSS(mg/l)	TDS(mg/l)
CW	0.47 ± 0.33 ^a	238.67 ± 2.40 ^a	333.70 ± 7.69 ^a	51.16 ± 1.27 ^a	276.34 ± 6.60 ^a
WW	3.10 ± 0.58 ^a	128.00 ± 6.00 ^a	605.58 ± 16.16 ^a	480.48 ± 22.46 ^a	102.52 ± 6.35 ^a
WWMOA	2.10 ± 0.12 ^a	256.33 ± 3.28 ^a	155.90 ± 1.37 ^a	27.20 ± 3.20 ^b	128.70 ± 2.00 ^a
WWA	1.65 ± 0.03 ^a	914.00 ± 7.02 ^a	134.50 ± 2.68 ^a	27.20 ± 4.35 ^b	108.53 ± 1.68 ^a
WWMOA	1.80 ± 0.58 ^a	992.00 ± 4.16 ^a	141.73 ± 0.95 ^a	20.06 ± 0.55 ^b	121.77 ± 0.41 ^a
WHO (Permissible limit)	5	1000	200	50	500

Values are means ± Standard Error Mean. Values with the same superscript (a) are significantly different at (p< 0.05) when compared to control down the group. Values with superscript (b and c) are not.

Table 3. Mean levels of chemical parameters before and after treatments

Group	pH	Total Hardness (mg/l)	BOD (mg/l)	COD (mg/l)	Total Alkalinity (mg/l)	Phosphate (mg/l)	Nitrate (mg/l)	Nitrite (mg/l)	Chloride (mg/l)	Fluoride (mg/l)	CO ₂ (mg/l)
CW	6.80 ± 0.03 ^a	86.36± 1.91 ^a	4.48± 0.14 ^a	12.21± 0.90 ^a	94.08 ± 0.58 ^a	0.40 ± 0.00 ^a	8.41± 0.08 ^a	0.03± 0.00 ^a	30.10± 0.72 ^a	0.00± 0.00 ^a	3.30± 0.12 ^a
WW	6.59 ± 0.17 ^b	183.50± 4.36 ^a	6.91± 0.17 ^a	78.85± 0.73 ^a	117.31± 1.06 ^a	0.85 ± 0.00 ^a	13.44± 0.18 ^a	0.79± 0.14 ^a	235.87± 5.28 ^a	0.02± 0.00 ^c	8.03± 0.03 ^a
WWMOA	6.82 ± 0.01 ^c	91.53± 1.43 ^c	3.93± 0.15 ^b	11.90± 0.51 ^b	4.43 ± 0.09 ^a	0.04 ± 0.00 ^a	0.37± 0.06 ^a	0.26± 0.10 ^a	62.53± 0.82 ^a	0.20± 0.03 ^a	1.43± 0.01 ^a
WWA	6.69 ± 0.02 ^b	65.23± 2.74 ^a	3.17± 0.09 ^a	9.30± 0.40 ^b	4.73 ± 0.19 ^a	0.02 ± 0.00 ^a	0.19± 0.01 ^a	0.23± 0.01 ^a	81.00± 1.11 ^a	0.24± 0.05 ^a	1.25± 0.03 ^a
WWMOA	6.96 ± 0.01 ^c	28.10± 0.67 ^a	3.65± 0.09 ^a	9.67± 0.44 ^a	3.47 ± 0.18 ^a	0.02 ± 0.01 ^a	0.13± 0.00 ^a	0.15± 0.00 ^a	43.03 ± 1.30 ^a	0.06± 0.01 ^c	0.54± 0.02 ^a
WHO (Permissible limit)	6.5-8.5	150	4	100	500	5	50	0.2	250	1.5	-

Table 4. Mean levels of metal concentrations before and after treatment (As compared with Control – Bottled water).

Group	Na (mg/l)	Mg (mg/l)	Ca (mg/l)	K (mg/l)	Cu (mg/l)	Cd (mg/l)	Zn (mg/l)	Fe (mg/l)
CW	16.54± 0.86 ^a	54.91 ±1.85 ^a	30.94 ±0.24 ^a	0.24 ± 0.08 ^a	0.39 ± 0.74 ^a	0.00010 ±0.00 ^a	1.37± 0.11 ^a	0.02 ± 0.00 ^a
WW	43.59± 0.38 ^a	84.22 ±3.97 ^a	99.33 ±0.36 ^a	0.56 ± 0.06 ^a	3.72 ± 0.11 ^a	0.00123 ±0.00 ^a	3.12 ±0.11 ^c	0.30 ± 0.04 ^c
WWMOA	8.05± 0.22 ^a	36.40 ±0.20 ^a	54.93 ±1.63 ^a	2.35 ± 0.13 ^a	0.37 ± 0.06 ^b	0.00010 ±0.00 ^c	1.22 ±0.10 ^a	1.88 ± 0.48 ^a
WWA	5.20 ±0.01 ^a	27.37 ±4.03 ^a	39.47 ±0.77 ^a	0.71 ± 0.01 ^a	0.28 ± 0.01 ^b	0.00010 ±0.00 ^c	0.92 ±0.06 ^a	0.95 ± 0.16 ^c
WWMOA	3.85 ±0.17 ^a	10.27 ±0.23 ^a	17.73 ±0.43 ^a	0.30 ± 0.00 ^c	0.07 ±0.01 ^a	0.00010 ±0.00 ^c	0.47 ±0.06 ^a	0.38 ± 0.33 ^c
WHO (Permissible limit)	200	50	20	<20	2	0.003	3	0.3

Values are means ± Standard Error Mean. Values with the same superscript (a) are significantly different at (p< 0.05) when compared to control down the group. Values with superscript (b and c) are not.

Table 5. Mean levels of microbial load before and after treatment (as compared with control – bottled water).

GROUPS	Total Coliform (Cfu)	E.coli (Cfu)
CW	1.0 ± 0.00 ^a	0.10 ± 0.00 ^a
WW	12.67 ± 1.33 ^a	12.00 ± 2.31 ^a
WWMOA	0.50 ± 0.00 ^b	0.20 ± 0.00 ^c
WWA	0.40 ± 0.00 ^b	0.30 ± 0.00 ^c
WWMOA	0.47 ± 0.03 ^b	0.30 ± 0.06 ^c
WHO (Permissible limit)	Nil	Nil

Values are means ± Standard Error Mean. Values with the same superscript (a) are significantly different at (p< 0.05) when compared to control down the group. Values with superscript (b and c) are not.

untreated water sample. Jahn [26] had earlier noted that *Moringa oleifera* is a natural cationic polyelectrolyte and flocculent chemically composed of basic polypeptides.

Initial values for Total Suspended Solids (TSS) before treatment were above permissible limits which is an indication of contamination. After the treatment, a reduction in TSS was recorded in all the treated groups.

It was observed that the pH of all samples as shown in Tables 4.3 and 4.4 were below the regulatory values but recorded a slight increase after the treatment. The slight increase is as a result of the hydroxyl group release by the

Moringa oleifera seed due to the presence of amino acids in the protein [24].

A reduction Total Hardness and Biochemical Oxygen Demand (BOD) of the water samples was observed after treatment to purify the test water samples. High BOD is due to the presence of microorganisms (high bacteria count) which is an indication of water contamination [27]. According to Muyibi and Evison [28], *Moringa* seed powder as a polyelectrolyte, removes hardness in water through adsorption and inter-particle bridging. Also, the finding of reduced Total alkalinity after water treatment is in agreement with results of previous study by Mangele [24] where it was observed that alkalinity reduced after the

treatment at 50 mg/l dose of *Moringa oleifera* seed powder.

Chloride concentrations as shown in Tables 4.3 and 4.4 before the treatment was high but after the treatment the level of chloride reduced except group 2 (untreated) in comparison to group 1 (control). In a previous study by Mangale [24]. Chlorides in river water was reduced by three fold after treatment with Moringa seeds. It is because cations from Moringa seed attract the negatively charged chloride ions present in water and neutralize the chlorides.

Metallic ions concentrations analysed such as sodium, potassium, magnesium, copper and zinc and calcium were higher when compared to control before treatment and lower after the treatment. In previous studies by Muyibi and Evison [29]; Rajeswari *et.al.*[30], Cadmium (Cd) was removed (85%) from water using a batch and continuous flow system in a fixed bed column by adding 20 g/L of *Moringa oleifera* seed flour at an initial pH of 6.5. Also, Alum combination with other coagulants gave higher reductions for turbidity, oil & grease, TSS, NH₃-N, COD, Zn, Pb, Cu, Mn and Fe in a previous study [31].

The present study also showed that after treatment, microbiological load of test water samples was reduced drastically indicating that *Moringa oleifera* seed powder and/or alum has the potential of reducing microbial load. An antimicrobial factor called glucomoringin (GMG) has been found in MO seeds, which is estimated to remove three log (99.99%) of coliforms in water [32], [33], [34]. Other studies have stated that the antimicrobial qualities of MO seed protein are attributable to membrane fusion [35].

V. CONCLUSION

This study revealed that quality indicator values for hand-dug well water in Ajogodo Community in Sapele Local Government Area of Delta State Nigeria are not in compliance with regulatory standards, which is an indication of contamination. It is most likely that the activities of the residents in the area such as open defecation, crude oil exploration and production, absence of constructed water drainage resulting in surface runoff into the wells after rainfall etc., continuously affect the quality of water in the wells thus, water obtained from them is unfit for human consumption. The study also showed that aluminium sulphate (Alum) and *Moringa oleifera* seed have potentials for water purification. Since *Moringa oleifera* does not have known toxic effect, it is therefore a safe water purification option for drinking water.

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